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TRANSFER FUNCTION, IMPULSE RESPONSE AND RERADIATED WAVEFORM FOR--ETC(U)

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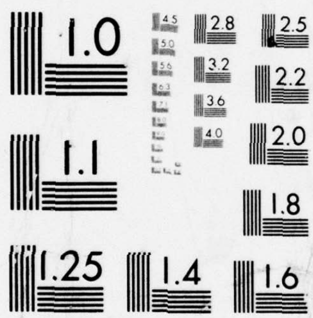

MICROCOPY RESOLUTION TEST CHART
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USL Technical Memorandum
2242-157-67

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(9) Technical memo.

TRANSFER FUNCTION, IMPULSE RESPONSE AND
RERADIATED WAVEFORM FOR AN ELLIPTICALLY SYMMETRIC
RERADIATION FUNCTION OF THE FORM z^ν, ν INTEGRAL
(USL PROGRAM NO. 0832) z to the nuth power, nu

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by

(10) Donald A. Stremsky

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U. S. NAVY UNDERWATER SOUND LABORATORY
FORT TRUMBULL, NEW LONDON, CONNECTICUT

TRANSFER FUNCTION, IMPULSE RESPONSE AND RERADIATED WAVEFORM FOR AN ELLIPTICALLY SYMMETRIC RERADIATION FUNCTION OF THE FORM z^ν, ν INTEGRAL (USL PROGRAM NO. 0832)

by

Donald A. Stremsky

USL Technical Memorandum No. 2242-157-67

1 May 1967

INTRODUCTION

A computational program has been prepared by the Information Processing Division to compute a particular Reradiation Function $w(\chi)$, Transfer Function $W(w,\rho)$, Impulse Response $w(t,\rho)$ and Reradiated Waveform $g(t,\rho)$ as defined below in terms of the incident plane wave pulse. This IBM 704 Program, designated USL Program No. 0832, is in Fortran II language and is described in Appendixes A and B. Similar computational programs are described in USL Tech. Memo. No. 2242-111-67 and 2242-156-67.

THEORY

Reference (a) contains a description of the mathematical model constructed and the theory behind considering reflection as a reradiation phenomenon.

This program computes for integer values of ν

(a) $a_1 a_2 \; w(\chi)$

(b) $W(w,\rho)$

(c) $kw\,(t,\mathbf{P})$

(d) $kg\,(t,\mathbf{P})$

where

(1) $$w(\mathbf{X}) = \begin{cases} \dfrac{\nu+1}{a_1 a_2 \pi}\left[1-\left(\dfrac{x_1}{a_1}\right)^2-\left(\dfrac{x_2}{a_2}\right)^2\right]^{\nu}, & x \in A \\ 0, & x \notin A \end{cases}$$

$$A: (x_1/a_1)^2 + (x_2/a_2)^2 \leq 1, \quad \nu > -1$$

(2) $$W(w,\mathbf{P}) = 2^{\nu+1}\,\Gamma(\nu+2)\,\frac{J_{\nu+1}(k\omega)}{(k\omega)^{\nu+1}}$$

$$k = \frac{1}{c}\left[(a_1 p_1)^2 + (a_2 p_2)^2\right]^{\frac{1}{2}}$$

(3) $$w(t,\mathbf{P}) = \begin{cases} \dfrac{\Gamma(\nu+2)}{k(\nu+\frac{1}{2})\,\pi^{\frac{1}{2}}}\left[1-(t/k)^2\right]^{\nu+\frac{1}{2}}, & |t| \leq k \\ 0, & |t| > k \end{cases}$$

(4) $$g(t,\mathbf{P}) = \int_{-\infty}^{\infty} f(\tau)\, w(t-\tau, \mathbf{P})\, d\tau$$

$$f(t) = \begin{cases} A(t)\cos\left\{\left[\omega_0 + \dfrac{\Delta\omega}{2}\left(\dfrac{t}{T}\right)\right]t + \varphi\right\}, & |t| < T \\ 0, & |t| > T \end{cases}$$

<u>Note</u>: Program #0837 as described in USL Tech. Memo. No. 2242-156-67 computes the above mentioned functions for half-integer values of ν.

COMPUTER PROGRAM DESCRIPTION

A nomenclature listing for USL Program No. 0832 is Appendix A,

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the Flow Chart is Appendix B, and the IBM 704 Fortran II Program is Appendix C.

The basic input data deck required by the program consists of four cards.

Table 1

Card Formats

Card No.	Cols.	Contents
1	1-8	a_1
	9-16	a_2
	17-24	x_1
	25-32	x_2
	33-40	c
	41-48	v
	49-51	ν
	52-54	ISKP (set equal to zero to compute Reradiation Function)
	55-57	JSKP (set equal to zero to compute Transfer Function)
	58-60	KSKP (set equal to zero to compute Impulse Response and Reradiated Waveform). For long jobs requiring the use of a dump tape at least one of the above options variables should not be set equal to zero
	61-63	NSTOP (in reference to Reradiated Waveform Array (k,t) NSTOP is the number of times t is incremented when k has its maximum value.
2	1-8	Initial value of ω
	9-16	Maximum value for ω
	17-24	Initial value of t
	25-32	Initial value of k (if not computed)
	35-36	KK (if set equal to zero, initial value of k will be computed)

Card No.	Cols.	Contents
2	39-46	Maximum value for k
3	1-8	λ_1 } components of Λ
	9-16	λ_2
	17-24	ν_1 } components of N
	25-32	ν_2
	33-40	Δx_1
	41-48	Δx_2
	49-50	Δt
	57-64	Increment of ω
	65-72	Δk
4	1-8	ω_0
	9-16	$\Delta\omega$
	17-24	Maximum value of τ
	25-32	Initial value of τ
	33-40	$\Delta\tau$
	41-48	φ

Formats:

Card No. 1 - Format 6F8.3, 5I3

2 - Format 4F8.3, 2X, I2, 2X, F8.3

3 - Format 9F8.3

4 - Format 6F8.3

Tape Units Required

Tape Unit No.	Tape Identification
3	Data Input
4	Values for Reradiation Function, Transfer Function & Impulse Response.

Tape Units Required (cont'd)

5	Calcomp Plotter containing values for Reradiation Function
6	Reradiated Waveform Array (k,t)
7	Transfer Function Array (k,w)
8	Impulse Response Array (k,t)
0	Dump Tape

SS5 must be down to dump
No other sense switches are used

Subroutines Required

Subroutine AMP computes the values for A(t) array referred to under equation (4).

Subroutine Besgen computes the values of cylindrical Bessel Functions (See reference (b) and Appendix C).

PROGRAM OUTPUT

Tape #4 contains:

(1) The values for the Z array plus the corresponding values for the Reradiation Function according to Format (1X, F10.5, 5X F10.5)

(2) The values for the product of k and w plus the corresponding values of the Transfer Function according to Format (1X, F10.5, 5X, F10.5).

(3) The values for t/k plus the corresponding values for the Impulse Response according to Format (1X, F10.5, 5X, F10.5)

Tape #5 contains:

The values for the Reradiation Function (Calcomp Plotter tape)

Tape #6 contains:

The Reradiated Waveform Array (k,t) according to Format (F10.5)

Tape #7 contains:

The Transfer Function Array (k,w) with Format (F10.5)

Tape #8 contains:

The Impulse Response Array according to Format (F10.5)

Tape #0 is a dump tape.

Notes: This program contains options to compute or not to compute any of the functions mentioned above. Tape Unit Nos. 6,7, and 8 can be used as input to USL Program No. 0809, "Representation of Surfaces: A Computer Program to Plot Contours and Draw Perspective Views", by Edward Beardsworth, Jr.

SUMMARY

An IBM 704 Fortran program, USL Program No. 0832, has been written to compute a particular Reradiation Function, Transfer Function, Impulse Response, and Reradiated Waveform in terms of the incident plane wave pulse.

D. A. Stremsky
D. A. STREMSKY
Mathematician

LIST OF REFERENCES

(a) Edward S. Eby, "Spectra and Waveforms of Bottom Reflected Pulses", USL Tech. Memo. No. 914-160-66, of 10 June 1966.

(b) E. P. Jensen, "Scattering of a Cylindrical Wave by a Symmetric Array of Cylinders", USL Tech. Memo. No. 907-173-64, of 12 October 1964.

APPENDIX A

NOMENCLATURE LISTING FOR USL PROGRAM NO. 0832

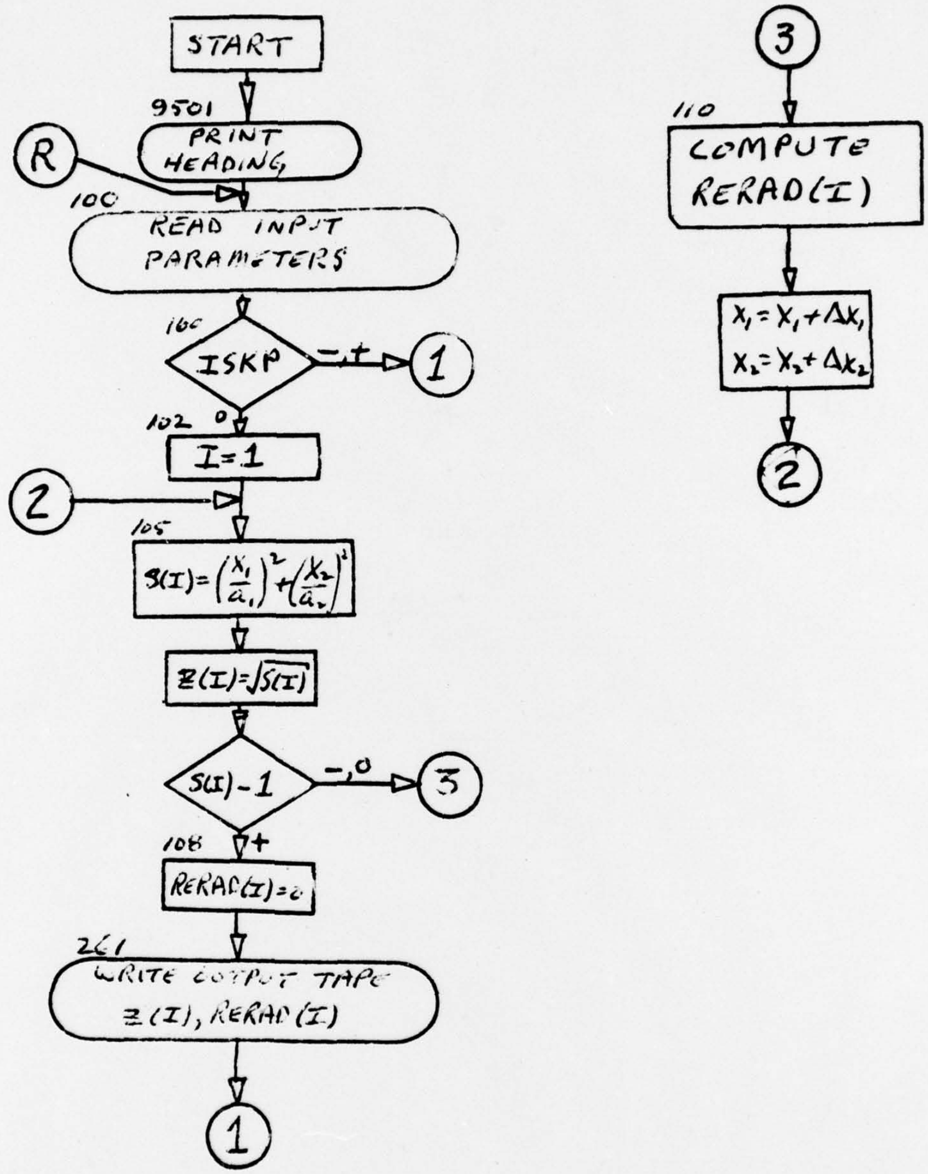
S(I)	$(x_1/a_1)^2 + (x_2/a_2)^2$
Z(I)	$\sqrt{S(I)}$
RERAD(I)	Element of Reradiation Function Array
TRFER(I)	Element of Transfer Function Array
AKW(LM,I)	$k\omega$
RESP(LM,I)	Element of Impulse Response Array
RATIO (LM,I)	t/k
GSUM (LM,J)	Element of Reradiated Waveform Array
A1	a_1
A2	a_2
X1	x_1
X2	x_2
C	c
V	v
N	ν
W	w
WMAX	Maximum value for w
T	Initial value for t
AK	k

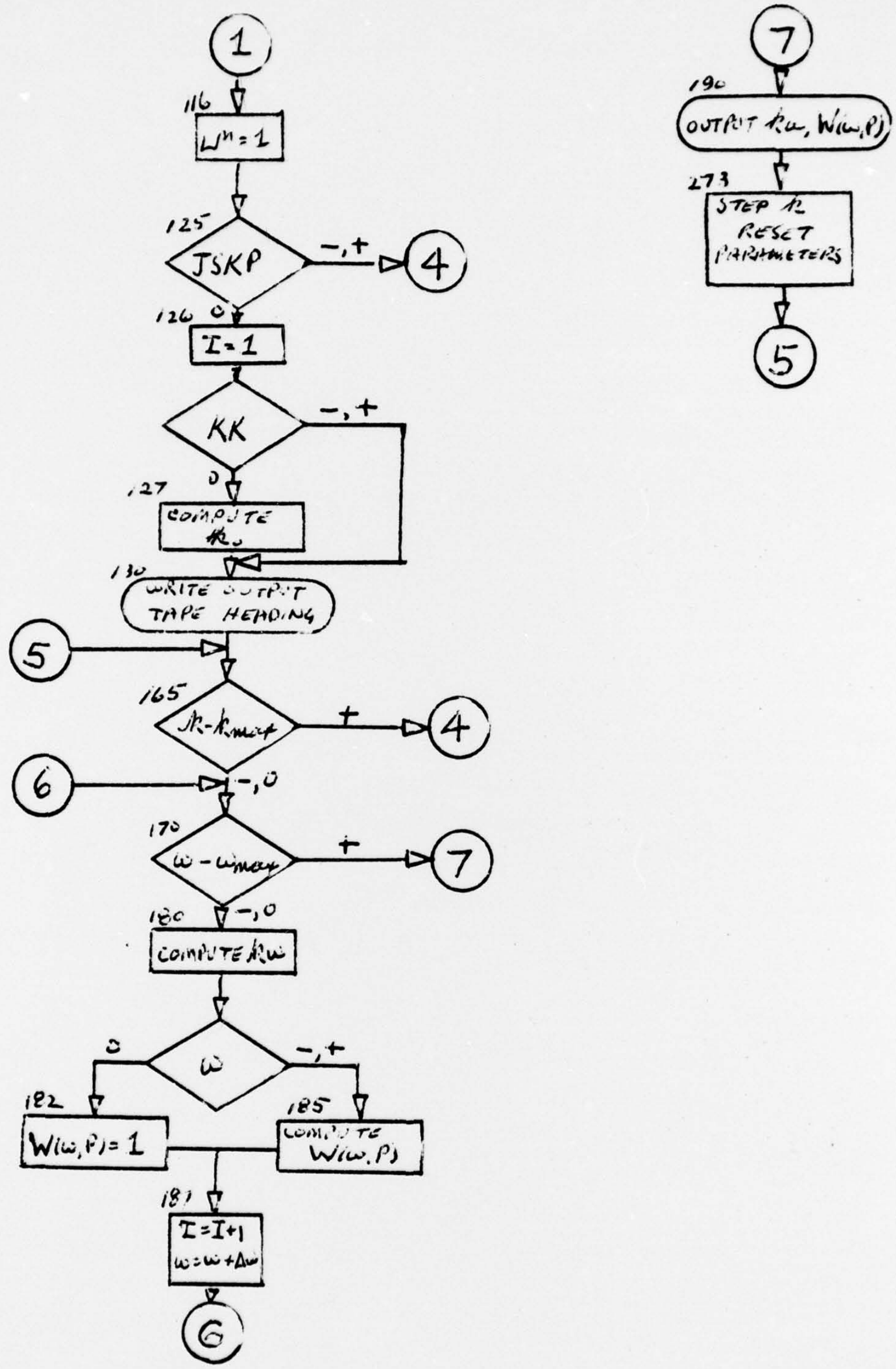
AKMAX	Maximum value for k
B1	$\left.\begin{matrix}\lambda_1\\ \lambda_2\end{matrix}\right\}$ components of Λ
B2	
B3	$\left.\begin{matrix}\nu_1\\ \nu_2\end{matrix}\right\}$ components of N
B4	
B5	Δx_1
B6	Δx_2
B7	Δt
B8	Increment of w
B10	$\Delta \tau$
B12	Δk
OMEGA	w_o
DELTA	Δw
TT	Maximum value of τ
TAV	Initial value of τ
PHI	φ

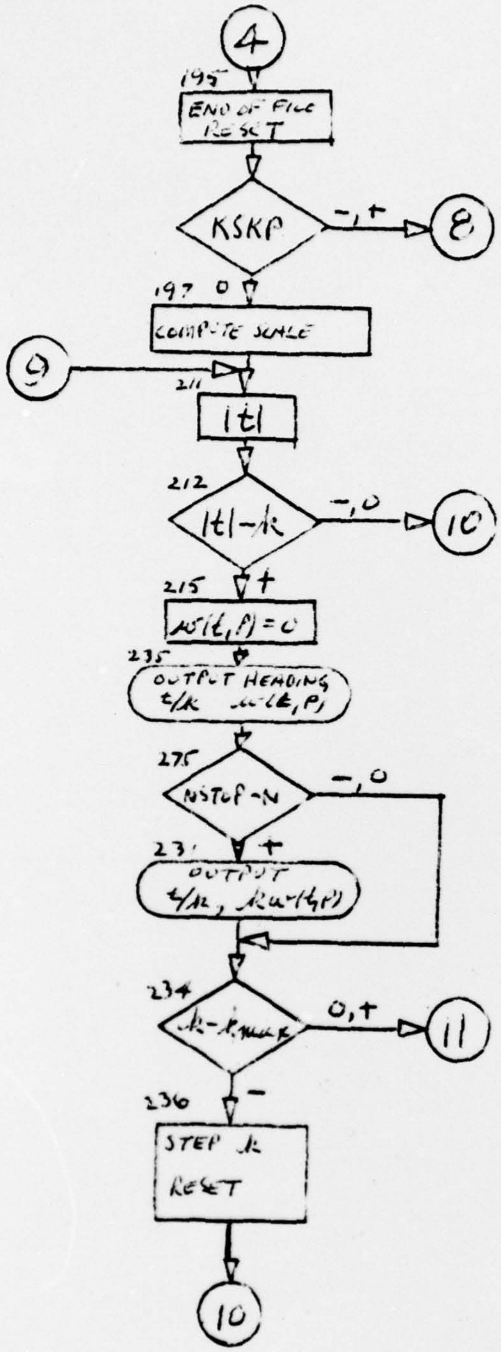
APPENDIX B

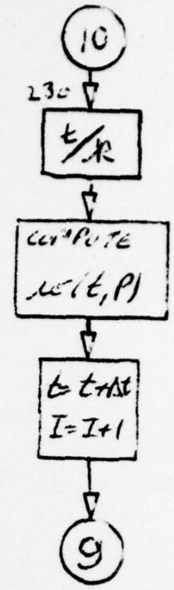
FLOW CHART FOR USL PROGRAM NO. 0832

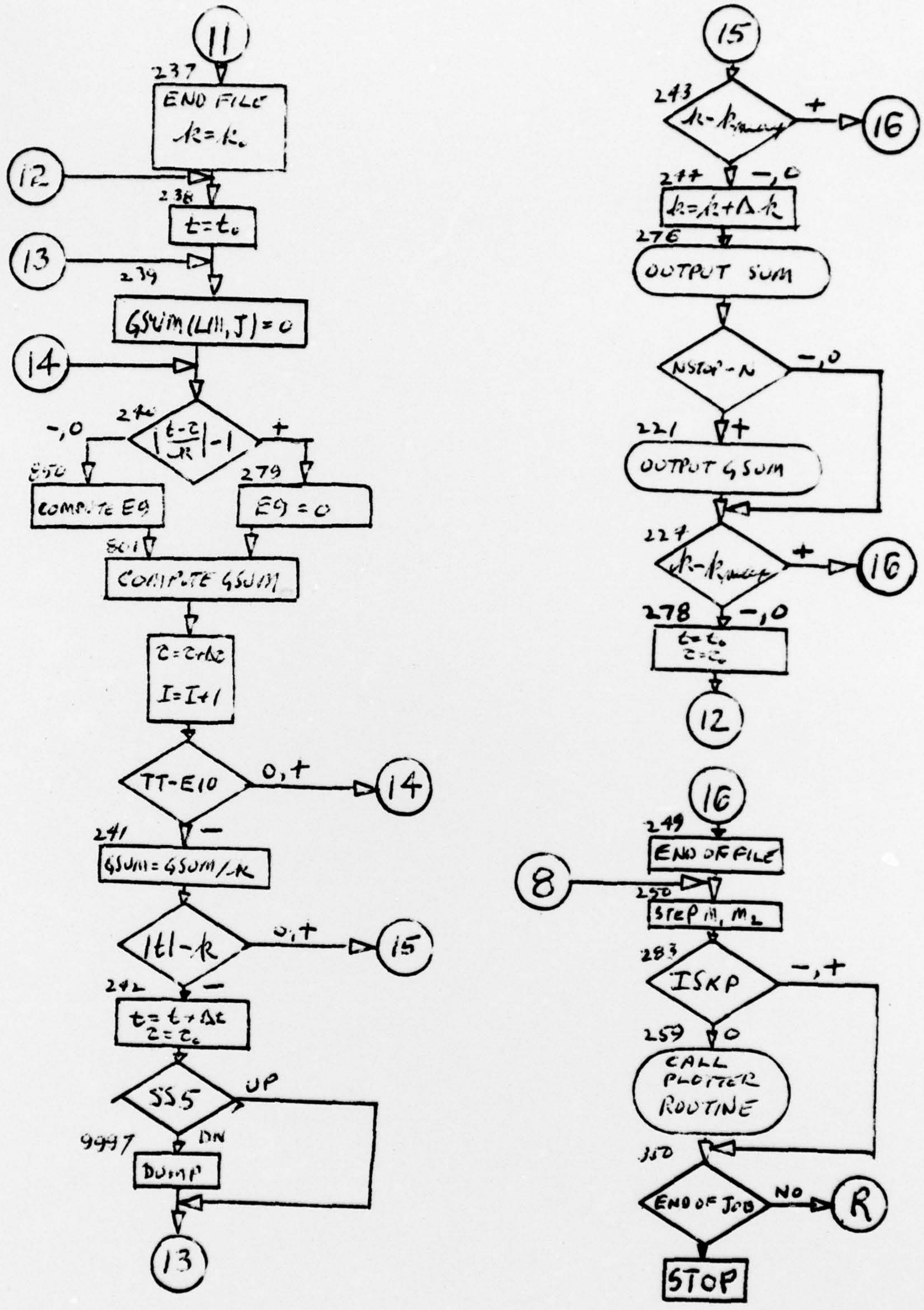
"RERADIATION FUNCTION, TRANSFER FUNCTION, IMPULSE RESPONSE (CASE 1A)"


START
9501
PRINT HEADING
R
100
READ INPUT PARAMETERS
100
ISKP
-,+
1
102
0
I=1
2
105
$S(I)=\left(\frac{X_1}{a_1}\right)^2+\left(\frac{X_2}{a_2}\right)^2$
$Z(I)=\sqrt{S(I)}$
S(I)-1
-,0
3
108
+
RERAD(I)=0
261
WRITE OUTPUT TAPE Z(I), RERAD(I)
1
3
110
COMPUTE RERAD(I)
$X_1=X_1+\Delta X_1$
$X_2=X_2+\Delta X_2$
2


1
116
125
JSKP
−,+
4
126
0
I=1
KK
−,+
0
127
COMPUTE
130
WRITE OUTPUT
TAPE HEADING
5
165
+
4
6
−,0
170
+
7
180
−,0
COMPUTE
0
ω
−,+
182
W(ω,P)= 1
185
COMPUTE
W(ω,P)
187
I=I+1
6
7
190
273
STEP 12
RESET
PARAMETERS
5


4
195
END OF FILE
RESET
KSKP
-, +
8
197 0
COMPUTE SCALE
9
211
|t|
212
|t|-k
-, 0
10
215 +
w(t,P)=0
235
OUTPUT HEADING
t/k w(t,P)
275
NSTOP-N
-, 0
23 +
OUTPUT
t/k, kw(t,P)
234
k-kmax
0, +
11
236 -
STEP k
RESET
10


10
230
t/k
COMPUTE
w(t,P)
t=t+Δt
I=I+1
9


11
237
END FILE
k=k₀
12
238
t=t₀
13
239
GSUM(LIII,J)=0
14
240
-,0
+
850
COMPUTE E9
279
E9=0
801
COMPUTE GSUM
τ=τ+Δτ
I=I+1
TT-E10
0,+
14
241
−
GSUM=GSUM/Δk
|t|-k
0,+
15
242
−
t=t+Δt
τ=τ₀
SS5
UP
9997
DN
DUMP
13
15
243
+
16
244
-,0
k=k+Δk
276
OUTPUT SUM
NSTOP-N
-,0
221
+
OUTPUT GSUM
277
+
16
278
-,0
t=t₀
τ=τ₀
12
16
249
END OF FILE
8
250
STEP M1, M2
283
ISKP
-,+
259
0
CALL
PLOTTER
ROUTINE
350
END OF JOB
NO
R
STOP

APPENDIX C

FORTRAN PROGRAM NO. 0832

```
C      RERADIATION FUNCTION,TRANSFER FUNCTION,IMPULSE RESPONSE (CASE 1A)
C      D.A.STREMSKY
       DIMENSION Z(500),RERAD(500),APPLE(500),AKW(50,50),B(200),TRFER(50,
      150),RESP(50,50),RATIO(50,50),S(500),GSUM(50,50),R(1000),IDUMP(18)
       DIMENSION BUFFER(1024),XAXIS(500),YAXIS(500)
STDJN  ALF    *0832
STECD  ALF    *
       WRITE OUTPUT TAPE 4,9501
 9501  FORMAT(1H1)
       READ INPUT TAPE 3,9502,DI
 9502  FORMAT(A5)
       IF(TDJN-DI)9503,9504,9503
 9503  PAUSE 6
 9504  WRITE OUTPUT TAPE 4,9502,DI
       WRITE OUTPUT TAPE 4,9505
 9505  FORMAT(10X32HD.A.STREMSKY,ROOM 3126,CODE 2242)
       READ INPUT TAPE 3,100,A1,A2,X1,X2,C,V,N,ISKP,JSKP,KSKP,NSTOP
  100  FORMAT(6F8.3,5I3)
       READ INPUT TAPE 3,101,W,WMAX,T,AK,KK,AKMAX
  101  FORMAT(4F8.3,2X,I2,2X,F8.3)
       READ INPUT TAPE 3,103,B1,B2,B3,B4,B5,B6,B7,B8,B12
  103  FORMAT(9F8.3)
       READ INPUT TAPE 3,104,AMEGA,DELTA,TT,TAU,B10,PHI
  104  FORMAT(6F8.3)
       W1=W
       AK1=AK
       T1=T
       TAU1=TAU
       NSTOP=NSTOP+1
       NP1=N+1
       NP2=N+2
       C1=N+1
       PIE=3.1415
       DEG=180./PIE
       C2=2.**C1
       C3=N+2
       NPROD=1
  150  DO 160 I=1,NP1
       NEWI=I
       NPROD=NPROD*NEWI
  160  CONTINUE
       PROD=NPROD
       C4=C2*PROD
       IF(ISKP)116,102,116
  102  I=1
  105  S(I)=(X1/A1)**2+(X2/A2)**2
       SX=S(I)
       Z(I)=SQRTF(SX)
       ZM1=S(I)-1.0
       IF(ZM1)110,110,108
  108  RERAD(I)=0.
       N1=I-1
       GO TO 261
  110  APPLE(I)=1.-S(I)
       IF(N)112,111,112
  111  PEAR=1.0
       GO TO 113
  112  PEAR=APPLE(I)**N
```

```
113 RERAD(I)=PEAR*C1/PIE
115 X1=X1+B5
    X2=X2+B6
    I=I+1
    GO TO 105
261 WRITE OUTPUT TAPE 4,251
251 FORMAT(1X36HZ                         RERADIATION FUNCTION)
    WRITE OUTPUT TAPE 4,252,(Z(I),RERAD(I),I=1,N1)
252 FORMAT(1X,F10.5,5X,F10.5)
    WRITE OUTPUT TAPE 4,253
253 FORMAT(///)
116 LM=1
125 IF(JSKP)195,126,195
126 I=1
    IF(KK)130,127,130
127 P1=B1-C*B3/V
    P2=B2-C*B4/V
    RB=(A1*P1)**2+(A2*P2)**2
    AK=SQRTF(RB)/C
130 I=1
263 WRITE OUTPUT TAPE 4,254
254 FORMAT(1X34HKW                          TRANSFER FUNCTION)
165 IF(AK-AKMAX)170,170,195
170 IF(W-WMAX)180,180,190
180 AKW(LM,I)=AK*W
    IF(W)185,182,185
182 TRFER(LM,I)=1.00000
    GO TO 187
185 BOP=AKW(LM,I)
    CALL BESGEN(BOP,B)
    BANG=BOP**C1
    TRFER(LM,I)=C4*B(NP2)/BANG
187 I=I+1
    W=W+B8
    GO TO 170
190 N2=I-1
    N4=LM
    WRITE OUTPUT TAPE 4,255,((AKW(LM,I),TRFER(LM,I),I=1,N2),LM=N4,N4)
255 FORMAT(1X,F10.5,5X,F10.5)
280 WRITE OUTPUT TAPE 7,273,((TRFER(LM,I),I=1,N2),LM=N4,N4)
273 FORMAT(F10.5)
    I=1
    W=W1
    LM=LM+1
    AK=AK+B12
    GO TO 165
195 I=1
    END FILE 7
    END FILE 7
    LM=1
    AK=AK1
    IF(KSKP)250,197,250
197 MPROD=1
    DO 210 M=1,NP1
    MNEW=2M-1
    MPROD=MPROD*MNEW
210 CONTINUE
    PROD2=MPROD
```

```
      C5=C4/(PIE*PROD2)
  265 WRITE OUTPUT TAPE 4,257
  257 FORMAT(1X34HT/K                        IMPULSE RESPONSE)
  211 ABSFT=ABSF(T)
  212 IF(ABSFT-AK)230,230,215
  215 RESP(LM,I)=0.
      N3=I-1
      GO TO 235
  230 RATIO(LM,I)=T/AK
      G2=RATIO(LM,I)**2
      G3=1.-G2
      FN=N
      EXP=FN+.5
      G4=G3**EXP
      RESP(LM,I)=C5*G4
      T=T+B7
      I=I+1
      GO TO 211
  235 N3=I-1
      N4=LM
      WRITE OUTPUT TAPE 4,258,((RATIO(LM,I),RESP(LM,I),I=1,N3),LM=N4,N4)
  258 FORMAT(1X,F10.5,5X,F10.5)
  282 WRITE OUTPUT TAPE 8,275,((RESP(LM,I),I=1,N3),LM=N4,N4)
  275 FORMAT(F10.5)
      N3P1=N3+1
      IF(NSTOP-N3P1)234,234,231
  231 DO 232 I=N3P1,NSTOP
      RESP(N4,I)=0.0
  232 CONTINUE
      WRITE OUTPUT TAPE 8,233,((RESP(LM,I),I=N3P1,NSTOP),LM=N4,N4)
  233 FORMAT (F10.5)
  234 IF(AK-AKMAX)236,237,237
  236 AK=AK+B12
      LM=LM+1
      I=1
      T=T1
      GO TO 230
  237 LM=1
       END FILE 8
      END FILE 8
      N5=0
      AK=AK1
      I=1
  238 D11=B7/AK
      T=T1
      J=1
      D12=ABSF(D11)
  239 GSUM(LM,J)=0.
  240 FRACT=TAU/TT
      E1=AMEGA+DELTA*FRACT/2.0
      E2=E1*TAU
      E3=E2+PHI
      E4=COSF(E3/DEG)
      CALL AMP(TAU,R)
      FCN=R(I)*E4
      TDIF=(T-TAU)/AK
      GRAPE=ABSF(TDIF)
      PLUM=GRAPE-1.0
```

```
      IF(PLUM)850,850,279
  279 E9=0.0
      GC TC 801
  850 E5=GRAPE/D12
      NE5=E5
      IA=NE5+1
      IB=NE5+2
      E6=GRAPE-RATIO(LM,IA)
      E7=E6/D11
      E8=1.0-E7
      RSPN=E7*RESP(LM,IB)+E8*RESP(LM,IA)
      E9=FCN*RSPN*B10
  801 GSUM(LM,J)=GSUM(LM,J)+E9
      TAU=TAU+B10
      I=I+1
      E10=ABSF(TAU)
      IF(TT-E10)241,240,240
  241 GSUM(LM,J)=GSUM(LM,J)/AK
      ABSFT=ABSF(T)
      IF(ABSFT-AK)242,243,243
  242 T=T+B7
      J=J+1
      TAU=TAU1
      IF(SENSE SWITCH 5)9997,9999
 9997 DO 9998 LK=1,15
      IDUMP(LK)=+0
 9998 CONTINUE
      IDUMP(16)=-6
      IDUMP(17)=+0
      IDUMP(18)=N5
      CALL DUMP(IDUMP)
 9999 GO TC 239
  243 IF(AK-AKMAX)244,244,249
  244 AK=AK+B12
      N3=J-1
      N4=LM
  276 WRITE OUTPUT TAPE 6,277,((GSUM(LM,I),I=1,N3),LM=N4,N4)
  277 FORMAT(F10.5)
      N3P1=N3+1
      IF(NSTOP-N3P1)224,224,221
  221 DC 222 I=N3P1,NSTOP
      GSUM(N4,I)=0.00000
  222 CONTINUE
      WRITE OUTPUT TAPE 6,223,((GSUM(LM,I),I=N3P1,NSTOP),LM=N4,N4)
  223 FORMAT (F10.5)
  224 N5=N5+J+NSTOP-N3
      IF(AK-AKMAX)278,278,249
  278 LM=LM+1
      T=T1
      TAU=TAU1
      I=1
      GC TO 238
  249 END FILE 6
      END FILE 6
  250 M1=N1+1
      M2=N1+2
  283 IF(ISKP)350,259,350
  259 CALL PLOTS (BUFFER(1024),1024,5)
```

```
      DO 260 J=1,N1
      XAXIS(J)=Z(J)
      YAXIS(J)=RERAD(J)
  260 CONTINUE
      CALL PLOT (0.0,5.0,-3)
      CALL SCALE (YAXIS,5.0,N1,1,10.0)
      CALL SCALE (XAXIS,10.0,N1,1,10.0)
      CALL LINE (XAXIS,YAXIS,N1,1,1,11)
      CALL AXIS (0.0,0.0,20HRERADIATION FUNCTION,20,5.0,90.0,YAXIS(M1),Y
     1AXIS(M2),10.0)
      CALL AXIS (0.0,0.0,1HZ,-1,10.0,0.0,XAXIS(M1),XAXIS(M2),10.0)
      CALL PLOT (0.0,0.0,999)
  350 READ INPUT TAPE 3,9502,ED
      IF (ED-TEOD)9503,9509,9503
 9509 WRITE OUTPUT TAPE 4,9511
 9511 FORMAT(4HOEND)
      END FILE 4
 9510 STOP 5
      END(1,1,0,1,1)
```

```
      SUBROUTINE BESGEN (X,B)
      DIMENSION B(200)
      BE = 1.0E-5
      Y=SINF(1.0)
      Z=COSF(1.0)
      D=SQRTF(2.0)
      DO 5 I=1,200
    5 B(I)=0.0
      IF (X-10.) 6,7,7
    6 RN=35.0/(3.5-LOGF(X))
      GO TO 8
    7 RN=1.05*X+25.
    8 N=RN
      IF (N-198) 9,9,206
  206 B(200) =0.0
      B(199) = BE
  207 AN = N
      STORE = 2.0*AN*B(199)/X-B(200)
      B(200) = B(199)
      B(199) = STORE
      N=N-1
      IF (N-198) 280,280,207
    9 B(N+2)=0.0
      B(N+1)=BE
  280 MAX=N+2
      DO 10 I=1,N
      J=MAX-I+1
      AN=J-2
      B(J-2)=2.0*AN*B(J-1)/X-B(J)
   10 CONTINUE
      CALL J0(X,BES)
      C1=BES/B(1)
      DO 15 I=1,MAX
      B(I)=B(I)*C1
   15 CONTINUE
   16 RETURN
      END(1,1,0,1,1)
```